3.17 Sewer Design Calculations

PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS

The Residence at Quail Ridge

Prepared By:

July 18, 2007

Zone Number	Connects to Zone	Number of Pumps in Zone	Accum Pumps in Zone	Gal/Day per Core	Max Flow per Core	Max Sim Ops	Max Flow (GPM)	Pipe Size (Inches)	Max Velocity (FPS)	Length of Main this Zone	Friction Loss Factor (ft/100ft)	Friction Loss this Zone	Accumulated Friction Loss (Feet)	Max Main Elevation	Minimum Pump Elevation	Static Head (Feet)	Total Dynamic Head (ft)
ıis spreadsheet was calculated using pipe diameters for: SDR21PVC											Friction loss calculations were based on a Constant for inside roughness o 150						
1.00	2.00	3	3	150.00	22.00	2	44.00	2.00	3.89	72.00	2.63	1.89	111.67	241.79	220.40	21.39	133.06
2.00	3.00	5	8	150.00	33.00	3	87.00	2.00	7.69	155.00	9.29	14.40	109.78	241.79	227.10	14.69	124.47
3.00	6.00	3	11	150.00	33.00	4	120.00	2.00	10.61	155.00	16.85	26.12	95.38	241.79	235.30	6.49	101.87
4.00	5.00	3	3	150.00	22.00	2	44.00	2.00	3.89	45.00	2.63	1.18	86.19	241.79	226.70	15.09	101.28
5.00	6.00	4	7	150.00	33.00	3	85.00	2.00	7.52	177.00	8.90	15.75	85.01	241.79	230.10	11.69	96.70
6.00	9.00	10	28	150.00	55.00	5	192.00	4.00	4.73	417.00	1.80	7.49	69.25	241.79	231.20	10.59	79.84
7.00	8.00	3	3	150.00	22.00	2	44.00	2.00	3.89	121.00	2.63	3.18	98.92	246.00	242.50	3.50	102.42
8.00	9.00	3	6	150.00	33.00	3	82.00	2.00	7.25	408.00	8.33	33.97	95.74	246.00	229.20	16.80	112.54
9.00	10.00	16	50	150.00	66.00	6	276.00	4.00	6.80	615.00	3.52	21.63	61.77	234.08	215.80	18.28	80.05
10.00	15.00	8	58	150.00	77.00	7	352.00	4.00	8.67	346.00	5.52	19.09	40.14	217.24	200.30	16.94	57.08
11.00	12.00	3	3	150.00	22.00	2	44.00	2.00	3.89	76.00	2.63	2.00	127.45	228.40	224.60	3.80	131.25
12.00	13.00	6	9	150.00	33.00	3	88.00	2.00	7.78	208.00	9.49	19.74	125.45	228.79	221.50	7.29	132.74
13.00	14.00	9	18	150.00	44.00	4	147.00	2.00	13.00	335.00	24.54	82.22	105.71	229.03	201.90	27.13	132.84
14.00	15.00	2	20	150.00	55.00	5	192.00	4.00	4.73	136.00	1.80	2.44	23.49	205.86	198.80	7.06	30.55
15.00	25.00	21	99	150.00	88.00	8	447.00	6.00	5.08	1,435.00	1.31	18.80	21.05	226.61	193.30	33.31	54.36
16.00	17.00	3	3	150.00	22.00	2	44.00	2.00	3.89	145.00	2.63	3.81	37.41	234.66	219.70	14.96	52.37
17.00	18.00	2	5	2775.00	33.00	3	79.00	2.00	6.99	259.00	7.77	20.13	33.60	234.66	225.10	9.56	43.16
18.00	24.00	9	14	150.00	44.00	4	151.00	4.00	3.72	397.00	1.15	4.57	13.47	234.66	226.60	8.06	21.53
19.00	20.00	2	2	150.00	22.00	2	44.00	2.00	3.89	40.00	2.63	1.05	33.12	238.07	229.80	8.27	41.39
20.00	23.00	3	5	150.00	33.00	3	86.00	2.00	7.61	136.00	9.09	12.37	32.06	238.07	228.80	9.27	41.33
21.00	22.00	3	3	150.00	22.00	2	44.00	2.00	3.89	138.00	2.63	3.63	44.79	237.93	233.10	4.83	49.62
22.00	23.00	5	8	150.00	33.00	3	87.00	2.00	7.69	231.00	9.29	21.46	41.16	237.93	229.80	8.13	49.29
23.00	24.00	12	25	150.00	55.00	5	207.00	4.00	5.10	523.00	2.06	10.80	19.70	237.93	229.30	8.63	28.33
24.00	25.00	4	43	150.00	66.00	6	255.00	4.00	6.28	219.00	3.04	6.65	8.90	234.66	231.50	3.16	12.06
25.00	25.00	1	143	1785.00	99.00	9	469.00	8.00	3.14	568.00	0.40	2.25	2.25	231.00	209.10	21.90	24.15

Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One.
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Prepared By:

PRELIMINARY PRESSURE SEWER - ACCUMULATED RETENTION TIME (HR)
The Residence at Quail Ridge

July 18, 2007

his spreadsheet was calculated using pipe diameters for: SDR21PVC

Zone Number	Connects to Zone	Accumulated Total of Pumps this Zone	Existing Pipe Size	Gallons per 100 Lineal Feet	Length of Zone	Capacity of Zone	Average Daily Flow	Average Fluid Changes per Day	Average Retention Time (Hr)	Accumulated Retention Time (Hr)
1.00	2.00	3	2.00	18.84	72.00	13.57	450	33.17	0.72	9.92
2.00	3.00	8	2.00	18.84	155.00	29.21	1,200	41.09	0.58	9.19
3.00	6.00	11	2.00	18.84	155.00	29.21	1,650	56.50	0.42	8.61
4.00	5.00	3	2.00	18.84	45.00	8.48	450	53.07	0.45	9.40
5.00	6.00	7	2.00	18.84	177.00	33.35	1,050	31.48	0.76	8.95
6.00	9.00	28	4.00	67.65	417.00	282.10	4,200	14.89	1.61	8.18
7.00	8.00	3	2.00	18.84	121.00	22.80	450	19.74	1.22	9.84
8.00	9.00	6	2.00	18.84	408.00	76.88	900	11.71	2.05	8.62
9.00	10.00	50	4.00	67.65	615.00	416.05	7,500	18.03	1.33	6.57
10.00	15.00	58	4.00	67.65	346.00	234.07	8,700	37.17	0.65	5.24
11.00	12.00	3	2.00	18.84	76.00	14.32	450	31.42	0.76	7.35
12.00	13.00	9	2.00	18.84	208.00	39.19	1,350	34.45	0.70	6.59
13.00	14.00	18	2.00	18.84	335.00	63.12	2,700	42.77	0.56	5.89
14.00	15.00	20	4.00	67.65	136.00	92.01	3,000	32.61	0.74	5.33
15.00	25.00	99	6.00	146.54	1,435.00	2,102.81	14,850	7.06	3.40	4.59
16.00	17.00	3	2.00	18.84	145.00	27.32	450	16.47	1.46	4.03
17.00	18.00	5	2.00	18.84	259.00	48.80	6,000	122.95	0.20	2.57
18.00	24.00	14	4.00	67.65	397.00	268.57	7,350	27.37	0.88	2.38
19.00	20.00	2	2.00	18.84	40.00	7.54	300	39.80	0.60	5.19
20.00	23.00	5	2.00	18.84	136.00	25.63	750	29.27	0.82	4.58
21.00	22.00	3	2.00	18.84	138.00	26.00	450	17.31	1.39	6.02
22.00	23.00	8	2.00	18.84	231.00	43.53	1,200	27.57	0.87	4.63
23.00	24.00	25	4.00	67.65	523.00	353.82	3,750	10.60	2.26	3.76
24.00	25.00	43	4.00	67.65	219.00	148.16	11,700	78.97	0.30	1.50
25.00	25.00	143	8.00	248.54	568.00	1,411.73	28,335	20.07	1.20	1.20

Note: This analysis is valid only with the use of progressive cavity type grinder pumps as manufactured by Environment One

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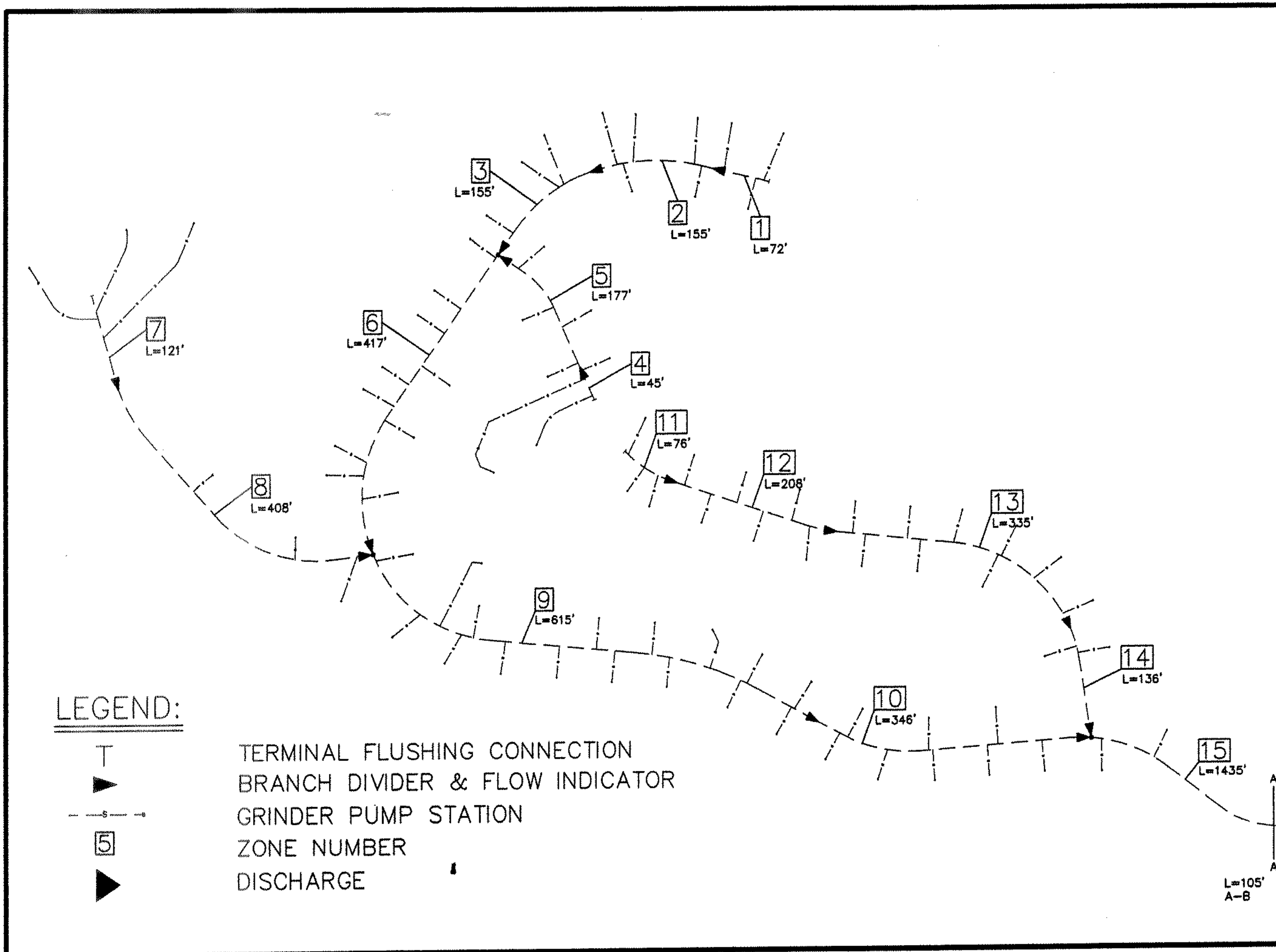

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GRINDER PUMP STATION
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ZONE NUMBER
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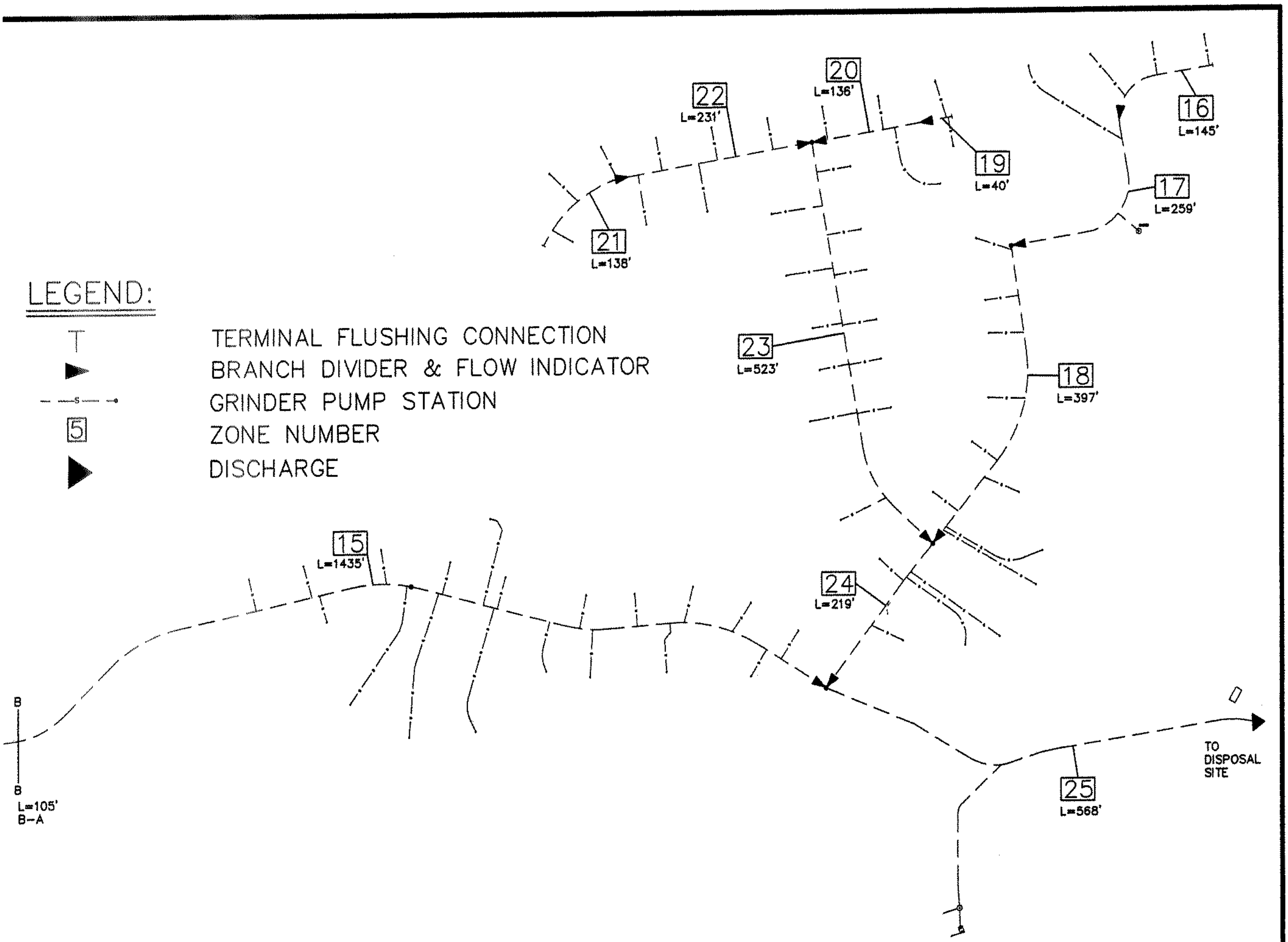

LEGEND:
TERMINAL FLUSHING CONNECTION
BRANCH DIVIDER & FLOW INDICATOR
GRINDER PUMP STATION
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Information Required

The information that should be assembled prior to initiation of the LPS system design includes:

- Topography map
- Soil conditions
- Climatic conditions (frost depth, low temperature and duration)
- Water table
- Applicable codes
- Discharge location
- Lot layout (with structures shown, if available)
- Total number of lots
- Dwelling type(s)
- Use and flow factors (seasonal occupancy or year-round, appliances, water supply sources)
- Area development sequence and timetable

Grinder Pump Station Size Selection

Use this table to select grinder pump models for the types of occupancy to be served.

Model	Recommended Flow (gpd)	Adequate for Managing ...
DH071	up to 700	Flow from one average single-family home, and up to two average, single-family homes where codes allow and with consent of the factory.
DH151	up to 1,500	Flow from up to two average single-family homes, and up to six average, single-family homes where codes allow and with consent of the factory.
DH152	up to 3,000	Flow from up to four average single-family homes, and up to 12 average, single-family homes with consent of the factory.
DH272	up to 5,000	Flow from up to six average single-family homes, and up to 20 average, single-family homes with consent of the factory.
DH502	up to 6,000	Flow from up to nine average single-family homes, and up to 24 average, single-family homes with consent of the factory.

Considerations include:

- Wetwell and discharge piping must be protected from freezing
- Model and basin size must be appropriate for incoming flows, including peak flows
- Appropriate alarm device must be used
- Suitable location

Daily flows above those recommended may exceed the tank's peak flow holding capacity and/or shorten the interval between pump overhauls. The company should be consulted if higher inflows are expected.

The final selection will have to be determined by the engineer on the basis of actual measurements or best estimates of the expected sewage flow.

Grinder Pump Placement

The most economical location for installation of the grinder pump station is in the basement of the building it will serve. However, due consideration must be given when choosing an indoor location. If there is a risk of damage to items located in the basement level, other provisions should be made during basement installation or an outdoor unit should be considered.

Considerations such as ownership of the pumps by a municipality or private organization and/or the need for outdoor accessibility frequently dictate outdoor, in-ground installations. For outdoor installations, all GP models are available with high density polyethylene (HDPE) integral accessways ranging in height up to 10 feet. By keeping the unit as close as possible to the building, the lengths of gravity sewer and wiring will be minimized, keeping installation costs lower while reducing the chances of infiltration in the gravity flow section.

AC power from the building being served should be used for the grinder pump. Separate power sources add to installation and O&M costs, decrease overall reliability and frequently represent an aesthetic issue.

When two dwellings are to be served by a single unit, the station is usually placed in a position requiring the shortest gravity drains from each home. With multi-family buildings, more than one grinder pump may be required.

Pipe Selection

The final determination of the type of pipe to be used is the responsibility of the consulting engineer. In addition, the requirements of local codes, soil, terrain, water and weather conditions that prevail will guide this decision.

Although pipe fabricated from any approved material may be used, most LPS systems have been built with PVC and HDPE pipe. Continuous coils of small-diameter, HDPE pipe can be installed with automatic trenching machines and horizontal drilling machines to sewer areas at lower cost.

Table 1 compares the water capacity of two types of PVC pipe commonly used: SDR-21 and Sch 40, and one type of HDPE, SDR-11. All three have adequate pressure ratings for low pressure sewer service.

Although both types of PVC pipes are suitable, the three parameters compared in Table 2 illustrate why SDR-21 is suggested as a good compromise between capacity, strength, friction loss characteristics and cost.

System Layout

A preliminary sketch of the entire pressure sewer system should be prepared (Figure 3). Pump models should be selected and their location (elevation) should be noted. The location and direction

Table 1 PIPE WATER CAPACITY *Gallons/100 feet of Pipe Length*			
Nominal Pipe Size (in.)	Sch 40 PVC	SDR 21 PVC	SDR 11 HDPE
1 1/4	7.8	9.2	7.4
1 1/2	10.6	12.1	9.9
2	17.4	18.8	15.4
2 1/2	23.9	27.6	—
3	38.4	40.9	33.5
4	66.1	67.5	55.3
5	103.7	103.1	84.5
6	150.0	146.0	119.9
8	260.0	249.0	203.2

Table 2 PVC PIPE COMPARISONS *Nominal Pipe Size = 2 in.*		
Parameter	**Sch 40**	**SDR 21**
Wall Thickness, in.	0.154	0.113
Inside Diameter, in.	2.067	2.149
50 gpm Friction Loss, ft/100 ft	4.16	3.44

of flow of each lateral, zone and main, and the point of discharge should be shown.

The system should be designed to give the shortest runs and the fewest abrupt changes in direction. "Loops" in the system must be avoided as they lead to unpredictable and uneven distribution of flow.

Although not shown in Figure 3, the elevation of the shutoff valve of the lowest-lying pump in each zone should be recorded and used in the final determination of static head loss. Since Environment One grinder pumps are semi-positive displacement and relatively insensitive to changes in head, precisely surveyed profiles are unnecessary.

Air/vacuum valves, air release valves and combination air valves serve to prevent the concentration of air at high points within a system. This is accomplished by exhausting large quantities of air as the system is filled and also by releasing pockets of air as they accumulate while the system is in operation and under pressure. Air/vacuum valves and combination air valves also serve to prevent a potentially destructive vacuum from forming.

Air/vacuum valves should be installed at all system high points and significant changes in grade. Combination air valves should be installed at those high points where air pockets can form. Air release valves should be installed at intervals of 2,000 to 2,500 feet on all long horizontal runs that lack a clearly defined high point.

Air relief valves should be installed at the beginning of each downward leg in the system that exhibits a 30-foot or more drop. Trapped pockets of air in the system not only add static head, but also increase friction losses by reducing the cross sectional area available for flow. Air will accumulate in downhill runs preceded by an uphill run.

Long ascending or descending lines require air and vacuum or dual-function valves placed at approximately 2000-foot intervals. Long horizontal runs require dual function valves placed at approximately 2000-foot intervals.

Pressure air release valves allow air and/or gas to continuously and automatically released from a pressurized liquid system. If air or gas pockets collect at the high points in a pumped system, then those pressurized air pockets can begin to displace usable pipe cross section. As the cross section of the pipe artificially decreases, the pump sees this situation as increased resistance to its ability to force the liquid through the pipe.

Air relief valves at high points may be necessary, depending on total system head, flow velocity and the particular profile. The engineer should consult Environment One in cases where trapped air is considered a potential problem.

Cleanout and flushing stations should be incorporated into the pipe layout. In general, cleanouts should be installed at the terminal end of each main, every 1,000 to 1,500 feet on straight runs of pipe, and whenever two or more mains come together and feed into another main.

Zone Designations

The LPS system illustrated in Figure 3 contains 72 pumps and is divided into 14 individually numbered zones. Division into zones facilitates final selection of pipe sizes, which are appropriate in relation to the requirements that flow velocity in the system is adequate and that both static and dynamic head losses are within design criteria. Assignment of individual zones follows from the relationship between the accumulating total number of pumps in a system to the predicted number that will periodically operate simultaneously (Table 3).

Table 4 was initially developed after careful analysis of more than 58,000 pump events in a 307-day period during the Albany project (4). It was extended for larger systems by application of probability theory. The validity of this table has since been confirmed by actual operating experience with thousands of large and small LPS systems during a 34-year period.

Using Figure 3, the actual exercise of assigning zones is largely mechanical. The single pump farthest from the discharge point in any main or lateral constitutes a zone. This and downstream pumps along the main are accumulated until their aggregate number is sufficient to increase the number of pumps in simultaneous operations by one, i.e., until the predicted maximum flow increases by 11 gpm.

Figure 3 shows that zones 1, 2 and 3 end when the number of pumps connected total 3, 6 and 9, and the number of pumps in daily simultaneous operation are 2, 3 and 4, respectively.

Any place where two or more sections of main join, or where the outfall is reached, also determines the end of a zone. This design rule takes precedence over the procedure stated above, as seen in zones 3, 4, 6, 8, 9, 11, 12, 13 and 14.

Completion of Pipe Schedule and Zone Analysis

The data recorded on the System Flow Diagram (Figure 3) is then transferred to Table 4.

Table 4 Column No.	Designation
1	Zone Number
2	Connects to Zone
3	Number of Pumps in Zone
4	Accumulated Pumps in Zone
11	Length of Main this Zone in Feet

Column 4 is completed by referring to Table 3, where the maximum number of pumps in simultaneous operation is given as a function of the number of pumps upstream from the end of the particular zone. The output of each zone will vary slightly with head requirements, but under typical conditions, the flow is approximately 11 gpm. Calculate the maximum anticipated flow for each zone by multiplying the number of simultaneous operations in Column 7 by 11 gpm and record the results in Column 8.

To complete columns 9, 10, 12 and 13, refer to Flow Velocity and Friction Head Loss table for the type of pipe selected — in this case, Table 5 for SDR-21. It will be seen that the engineer will frequently be presented with more than one option when selecting pipe size. Sometimes a compromise in pipe size will be required to meet present needs as well as planned future development. As a general rule, pipe sizes should be selected to minimize friction losses while keeping velocity near or above 2 feet per second.

For example, Zone 1 has a maximum of two pumps running (Column 7). Table 5 offers a choice of 1.25-inch, 1.5-inch or 2-inch pipe. 1.5-inch pipe is selected since flow velocity equals 3.04 ft/sec and friction loss equals 2.15 ft/100 ft. Since the zone is 205 feet in length (Column 11), the total friction loss (Column 13) is:

Table 3
MAXIMUM NUMBER OF GRINDER PUMP CORES OPERATING DAILY

Number of Grinder Pump Cores Connected	Maximum Daily Number of Grinder Pump Cores Operating Simultaneously
1	1
2–3	2
4–9	3
10–18	4
19–30	5
31–50	6
51–80	7
81–113	8
114–146	9
147–179	10
180–212	11
213–245	12
246–278	13
279–311	14
312–344	15
345–377	16
378–410	17
411–443	18
444–476	19
477–509	20
510–542	21
543–575	22
576–608	23
609–641	24
642–674	25
675–707	26
708–740	27
741–773	28
774–806	29
807–839	30
840–872	31
873–905	32
906–938	33
939–971	34
972–1,004	35